Towards an energy-based parameter for photovoltaic classification (PhotoClass)

Aim: Energy prediction instead of peak efficiency - A realistic key standard for PV industry

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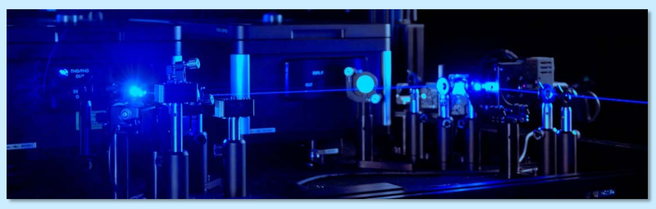
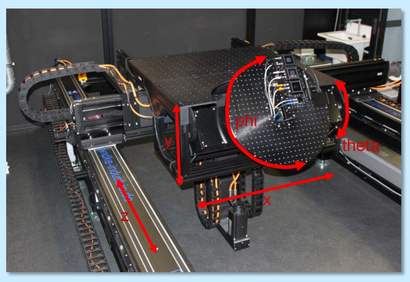
Need for energy rating

- o € 50 billion annual market for PV, with strong future growth
- o Sales currently based on "watts-peak" for conditions that are never achieved in operation, while the most important parameter for investors is energy yield
- o Financial success of installations depends on energy generation rather than power values and there are cases that lower efficiency devices produce more energy
- o Currently available metrology does not enable (judicial) expert assessors to clarify defects within the scope of warranty
- o Focus on "watts-peak" can distort R&D efforts

Structure of the approach





Develop an energy-based metric for photovoltaics

- Development of energy-based metric and uncertainty assessment
- Standard and geospatial climatic datasets
- Measurement strategies for economical and accurate energy assessments

$$I(T,E) = \int s(\lambda,T,E,\Omega)\cdot E_\lambda(\lambda,\Omega)\,d\lambda\,d\Omega$$

Providing input parameters

Detector characterization

- New techniques for detector characterization
- Linearity characterization of detector
- Temperature dependence of detector
- Angular dependence of detector

Source characterization

- Characterization of the solar spectrum
- Spectral characterization of pulsed solar simulators
- Characterization of LED based solar simulator
- Simultaneous uniformimeter based on photodiode array
- Uncertainty of spectral measurements

Calibration

Measurement

Reference devices

- Definition of required specs and selection of reference devices
- Development and optimization of new reference devices
- Validation of various improved calibration/characterization methods

Consortium and REGs

PTB – Physikalisch-Technische Bundesanstalt Braunschweig und Berlin

INTA

European Commission

LNE – Le progrès, une passion à partager

MIKES – Centre for metrology and accreditation

NPL – National Physical Laboratory

VSL

Scuola universitaria professionale della Svizzera italiana – SUPSI

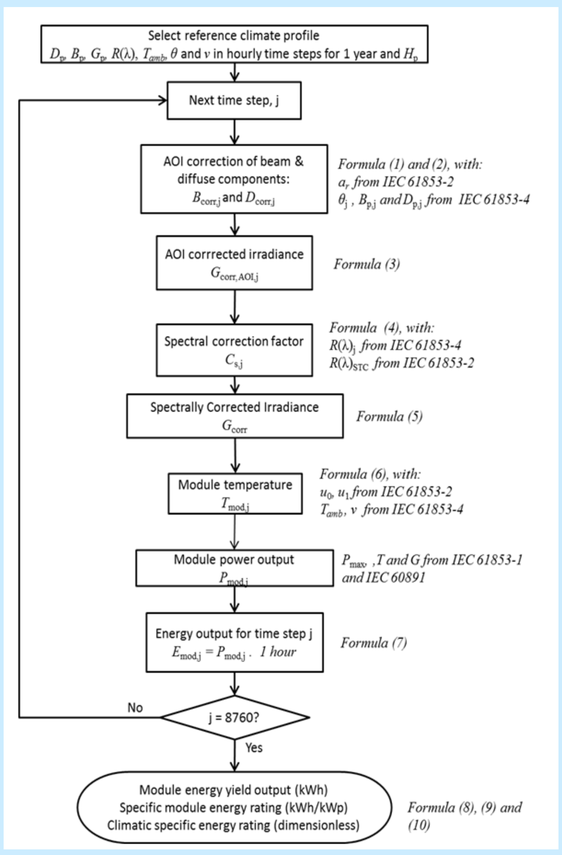
TÜVRheinland® – Genau. Richtig.

Fraunhofer ISE Institut Solare Energiesysteme

Loughborough University

ISFH

Results



Flow chart of calculation procedure

Input module data

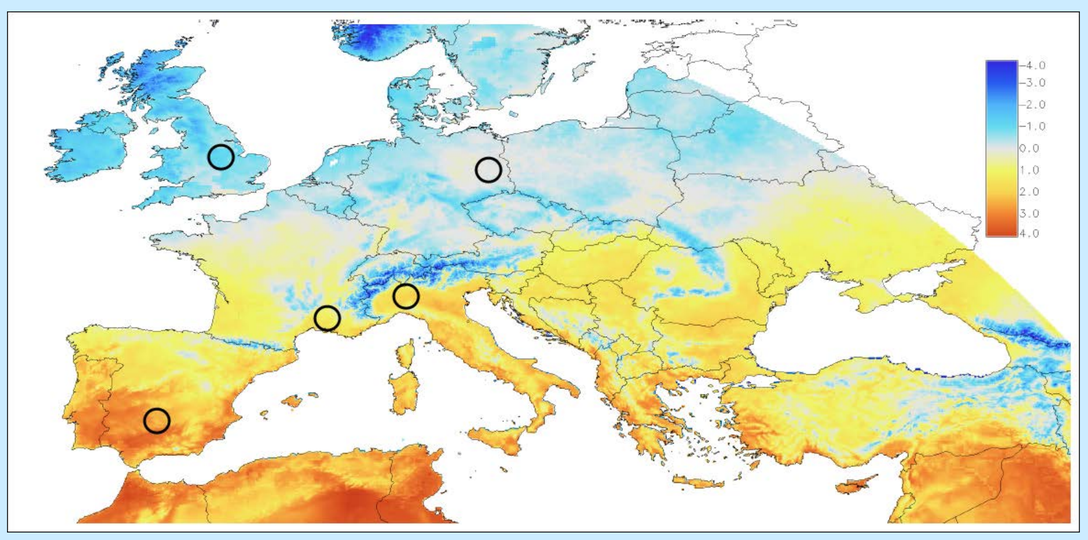
- Matrix of P_{max} vs irradiance and module temperature
- Thermal coefficient u_0 and u_1 for wind dependance
- Angular of incidence responsivity
- Spectral responsivity

Input climatic data

- Time
- Sun evaluation and incident
- Wind speed
- Ambient temperature
- Global horizontal irradiance
- Global inplane irradiance
- Direct inplane irradiance
- Diffuse inplane irradiance
- Spectrum for a set of bands

	A	B	C	D	E	F	G	H	I	J	K	L	
1	Day in Year	Hour	Sun elevation (degrees)	Sun incidence angle	Wind speed	Ambient temperature	Direct Normal Irradiance	Global horizontal irradiance	Global in-plane irradiance	Direct in-plane irradiance	Spectral irradiance 306.8-327.8nm	327.8-362.5nm	362.5-407
4273	178	23	0,000	0,000	1,596	15,320	0,000	0,000	0,000	0,000	0,000	0,000	
4274	179	0	0,000	0,000	3,427	13,840	0,000	0,000	0,000	0,000	0,000	0,000	
4275	179	1	0,000	0,000	3,234	13,160	0,000	0,000	0,000	0,000	0,000	0,000	
4276	179	2	0,000	0,000	3,035	12,480	0,000	0,000	0,000	0,000	0,000	0,000	
4277	179	3	0,000	0,000	2,843	11,800	0,000	0,000	0,000	0,000	0,000	0,000	
4278	179	4	0,000	0,000	3,093	12,220	0,000	0,000	0,000	0,000	0,000	0,000	
4279	179	5	8,832	0,379	3,358	12,640	127,659	68,100	52,216	0,846	0,006	0,993	
4280	179	6	18,998	13,013	3,641	13,060	415,326	235,200	188,904	93,522	0,423	4,183	
4281	179	7	29,611	26,065	3,171	15,410	578,218	416,900	383,378	254,062	1,330	8,387	
4282	179	8	40,374	39,395	2,717	17,750	662,884	588,100	582,583	420,705	2,549	12,915	
4283	179	9	50,902	52,909	2,272	20,100	505,110	666,700	682,589	402,917	3,614	16,064	
4284	179	10	60,487	66,541	1,361	21,280	788,403	861,200	910,144	723,238	5,018	20,832	
4285	179	11	67,499	80,230	0,470	22,450	859,642	946,600	1012,948	847,175	5,856	23,389	
4286	179	12	68,957	85,942	0,482	23,630	745,623	923,000	985,680	743,754	5,860	23,143	
4287	179	13	63,885	72,272	0,378	23,380	516,084	802,600	839,761	491,577	5,112	20,450	
4288	179	14	55,094	58,608	0,394	23,120	529,086	737,600	762,403	451,641	4,346	18,262	
4289	179	15	44,842	45,037	0,528	22,870	390,271	581,100	582,242	276,143	3,069	14,034	
4290	179	16	34,119	31,620	0,511	22,240	175,961	373,700	363,159	92,255	1,695	8,916	
4291	179	17	23,405	18,439	0,555	21,610	16,615	162,800	158,836	5,255	0,587	3,908	
4292	179	18	13,017	5,609	0,640	20,980	0,000	55,200	53,850	0,000	0,110	1,220	
4293	179	19	3,248	0,000	0,931	19,640	0,000	27,500	26,267	0,000	0,000	0,375	
4294	179	20	0,000	0,000	1,361	18,310	0,000	0,000	0,000	0,000	0,000	0,000	
4295	179	21	0,000	0,000	1,836	16,970	0,000	0,000	0,000	0,000	0,000	0,000	

Starting with definition data for one standard reference climatic profile: 24x365 = 8760 lines and 39 columns



Map of difference in MPR between CdTe and c-Si modules, given in percentage points. Marked are locations for that climatic profiles are provided

T. Huld et al: „Photovoltaic Energy Rating Data sets for Europe “ in Solar Energy

Summary

- o Draft standards of 61853 series “Photovoltaic (PV) modules performance testing and energy rating” submitted to IEC
  - IEC 61853-2 “Spectral response, incidence angle and module operating temperature measurements”: Approved for FDIS voting
  - IEC 61853-3 “Energy Rating of PV Modules”: 1st CD
  - IEC 61853-4 “Standard reference climatic profiles”: 1st CD
  - All important players are involved to enable success

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